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US ARMY MEDICAL RESEARCH LABORATORY

FORT KNOX, KENTUCKY

REPORT NO. 356
13 August 1953

LOCALIZATION OF SOUND ON ICE AND SNOW*

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*Subtask under Psychophysiological Studies, USAMRL Project No. 6-95-20-001, Subtask, Noise and Vibration Problems.

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LOCALIZATION OF SOUND ON ICE AND SNOW*

by

Carl A. Silver and John L. Fletcher

from

Experimental Psychology Department
US ARMY MEDICAL RESEARCH LABORATORY
FORT KNOX, KENTUCKY

*Subtask under Psychophysiological Studies, USAMRL Project No. 6-95-20-001, Subtask, Noise and Vibration Problems.

Report No. 356
Project No. 6-95-20-001
Subtask USAMRL S-3
MEDEA

ABSTRACT

LOCALIZATION OF SOUND ON ICE AND SNOW

OBJECT

To investigate the ability of subjects to locate the origin of signals over ice or snow surfaces.

RESULTS

Subjects were able to localize the direction of sounds better over snow surface than over ice.

RECOMMENDATIONS

It has been demonstrated that localization of sound on snow surfaces is superior to localization on ice surfaces. As an aid to communication, investigation should be made of intelligibility over ice and snow.

Submitted 10 June 1958 by:
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LOCALIZATION OF SOUND ON ICE AND SNOW*

I. INTRODUCTION

Military operations in Arctic environments are contingent upon proper utilization of the physical and psychological characteristics of those assigned there. Efficient utilization of human capabilities hinges upon an understanding of the interactions of these abilities with different environmental factors. For example, under Arctic conditions of reduced visibility men may rely upon the sense of hearing more than they do upon visibility. Little is now known about the interaction of various Arctic conditions such as ice or snow surfaces, high wind velocities, etc., and various auditory abilities (i.e., localization, detection, etc.). The type of ground cover, e.g., ice with its reflective surface or snow with its more absorptive surface, may have some effect upon the identification and localization of sounds.

This study is an attempt to determine some of the factors important in the localization of the direction of sounds under Arctic conditions.

II. METHOD

A. Design

The effects of four variables were studied in this investigation.

1. Surface: The surfaces were glare ice or a 1-to-2 inch cover of fresh uncrusted snow.

2. Subject Elevation: The subjects were tested in both the prone and standing positions.

3. Stimulus Elevation: Stimuli were produced by transducers located either 1.5 or 6 feet above ground level.

4. Pitch: Stimuli were tones of 400 and 1000 cps.

5. Subjects: Six young, adult, male soldiers made judgments as to location of the stimulus source.

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*The writers wish to acknowledge the efforts of Sp-3 Donald Wargo, Sp-3 Roy McDonald, Pfc Henry Benedict, and Pvts E. L. Lunt and E. St. Martine in the collection and analysis of the data of this study. The invaluable contribution of Dr. A. J. Riopelle must also be recognized here. Without his counsel the study could not have been made.

Combinations of these variables were presented according to a 2 x 2 x 2 factorial design. Every individual received 104 trials in each of two experiments. Each set of 104 trials was broken down into two sets of 52, one set of 52 trials over a snow surface, the other over ice. Every group of 52 trials was composed of two sets of 26 trials each, one while the subject was standing, the other while prone. Each set of 26 was arranged so that half of the trials were from the upper loudspeaker of each pair while the other half were from the lower. A random procedure was used to determine the order of all experimental trials. Similarly, half of the 26 trials were of a frequancy of 1000 cps while the other half were of 400 cps. In addition, each of the thirteen azimuthal locations appeared twice in a set of 26 trials, once with an upper loudspeaker, once with a lower loudspeaker.

The study was conducted at Camp McCoy, Wisconsin, during the month of February, 1958. The experimental apparatus was erected on the ice in the middle of a lake. Clearance to the right or left of the subject was at least 150 feet, and at least 300 feet to the nearest bank to the front or rear of the subject. For the ice condition, all snow was swept off the ice in the area shown in Figure 1. The equipment stayed in place for the snow condition, the only difference being that 1 to 2 inches of snow covered the area. No data were collected when the wind was blowing because the wind noise masked the experimental stimuli.

The average ambient sound pressure level (as measured by a General Radio Model 759-B sound-level meter using the A scale, slow setting) was 31 db in the absence of a signal. When the 400 or 1000 cps signals were on the SPL was 40 db.

B. Subjects

Six subjects ranging from 23 to 25 years of age were run. All subjects had normal hearing (down no more than 10 db from zero hearing loss) for the octave frequencies from 250-2000 cps.

C. Apparatus

The apparatus is shown in the block diagram in Figure 2. The 13 stands holding the speakers were spaced 15 degrees apart on an arc of 30 feet in radius, this subtending an arc of 180 degrees. On each stand were located two earphones which functioned as loudspeakers. The upper phone was elevated 6 feet above the surface while the lower phone was elevated 1.5 feet. The subject stood at the center of the semicircle and reported his observations by calling off the number of the stand from which he believed the last stimulus had originated. These numbers were prominantly displayed on each stand. The earphonse used were matched within 1 db at 400 and 1000 cps.

D. Procedures

All subjects had at least 104 training trials before any experimental trials were made. There was no noticable improvement after the first 52 trials. Instructions to the subjects were as follows: "Look straight ahead of you at stand 7. When you hear a signal, as soon as it is turned off, call out the number of the stand you believe it came from. Do not look at the stand until the signal is turned off."

The experimenters turned on the signal for about one second, turned it off, then recorded the subject's answer. Half the subjects started their trials from the prone position, half from the standing position. All trials on the ice were completed before trials on the snow were begun.

III. RESULTS

The two experiments (Experiment I and Experiment II) which constitute this experiment were analyzed separately using analysis-of-variance methods. In the first experiment no significant differences were found.

In the second experiment one significant difference was obtained (see Table 1). The main effect, "surfaces", (ice and snow) was significant at beyond the .01 level. In order to determine whether the observance of significant differences between conditions in this experiment was due to a lack of power in the experiment, the minimum separation of sound sources that would have been detected under these conditions was calculated for the 1% level of confidence. The figure obtained was .19 separation units between adjacent speakers (which were 15° apart). Therefore, a difference between conditions of about 3° would have been significant at the 1% level of confidence.

Localization over snow was better than localization over ice. This might be explained by considering that the decreased amount of reflected waves from snow as compared to ice probably resulted in fewer conflicting localization cues. Sound would undoubtedly be propagated farther over ice surfaces but, as we have shown, would be localized with regard to direction better over snow.

IV. SUMMARY

Localization of sound for direction was done over ice and snow. Subjects were able to indicate the origin of sound more correctly over snow surface than over ice.

V. RECOMMENDATIONS

It has been demonstrated that localization of sound is superior on snow surfaces compared with ice surfaces. As an aid to communication, investigation should be made of intelligibility over ice and snow.

TABLE 1

ANALYSIS OF VARIANCE, EXPERIMENT II

Source	df	Mean Square	F
1. Standing vs. Prone Position (P)	1	23.01	0.017
2. High vs. Low Microphone Elevation (E)	1	2100.01	1.59
3. Stimulus Frequency, 400 or 1000 cps (F)	1	437.76	0.33
4. Ground Cover, Ice or Snow (C)	1	9983.76	7.55*
5. P x E	1	5.51	0.004
6. P x F	1	1846.26	1.40
7. P x C	1	3048.76	2.31
8. E x F	1	1225.51	0.93
9. E x C	1	1725.51	1.31
10. F x C	1	2614.59	1.98
11. P x F x C	1	263.34	0.20
12. E x F x C	1	3564.84	2.70
13. P x E x F	1	508.76	0.38
14. P x E x C	1	19.26	0.015
15. P x E x F x C	1	595.01	0.45
16. Pooled Interactions With Subjects	95	1321.96	

*Significant Beyond the 1% Level of Confidence.

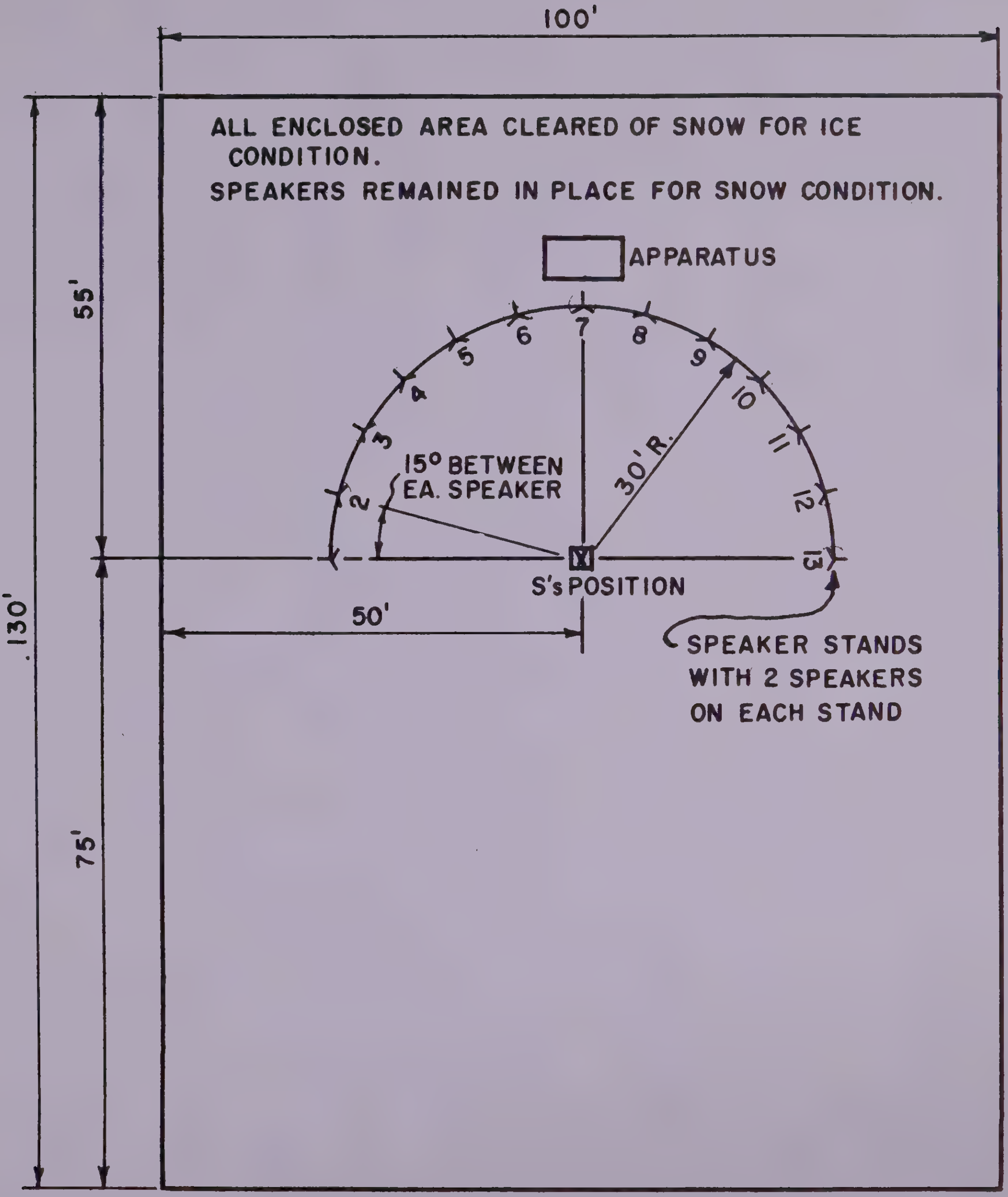
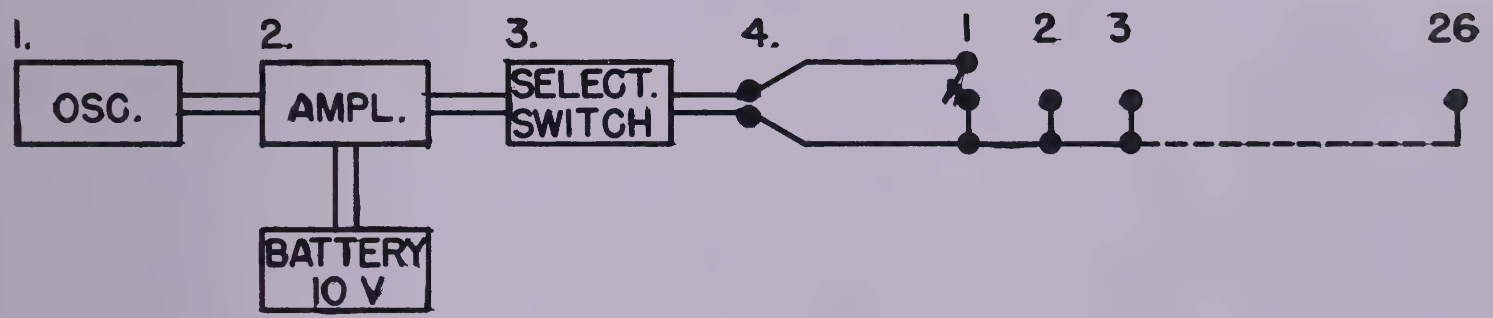

100'
ALL ENCLOSED AREA CLEARED OF SNOW FOR ICE CONDITION.
SPEAKERS REMAINED IN PLACE FOR SNOW CONDITION.
APPARATUS
2
3
4
5
6
7
8
9
10
11
12
13
15° BETWEEN EA. SPEAKER
30' R.
S's POSITION
50'
SPEAKER STANDS WITH 2 SPEAKERS ON EACH STAND
55'
75'
130'

Fig. 1. Experimental set-up on the lake.



1. GENERAL RADIO TRANSISTOR OSCILLATOR MODEL 1307-A.
2. BELL MOBILE AMPLIFIER MODEL 3717-MB
3. LOCALLY CONSTRUCTED SELECTOR SWITCH WITH 26 SWITCHING CONNECTIONS TO PERMIT ACTIVATING ONE SPEAKER AT A TIME
4. PERMOFLUX MODEL BD-HS-17B MATCHED EARPHONES USED AS SPEAKERS

Fig. 2. Block diagram of the apparatus.

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